Bringing the BlueZ back to Android

Marcel Holtmann

San Jose, 2014
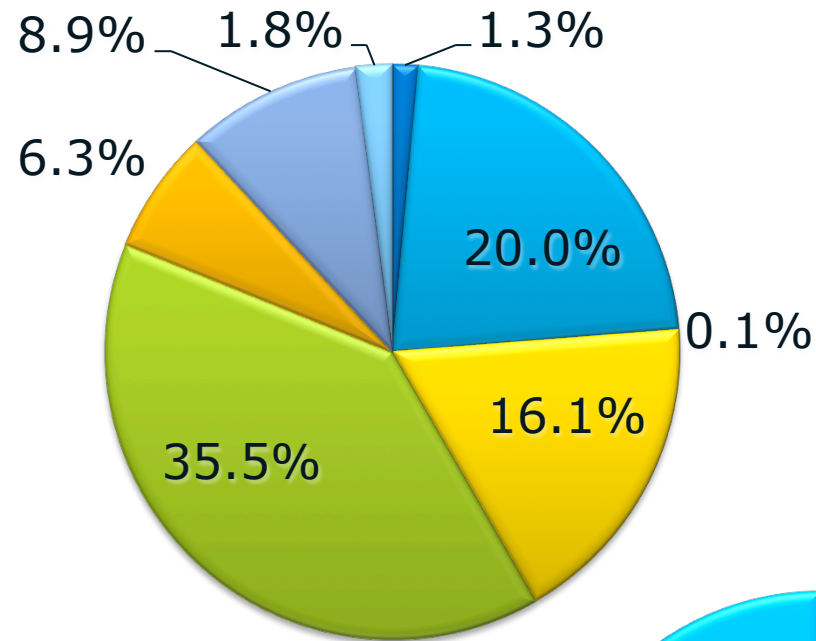
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New solutions for Bluetooth support on Android platform

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BlueZ
Android 4.1 and before

Bluedroid
Android 4.2 and later

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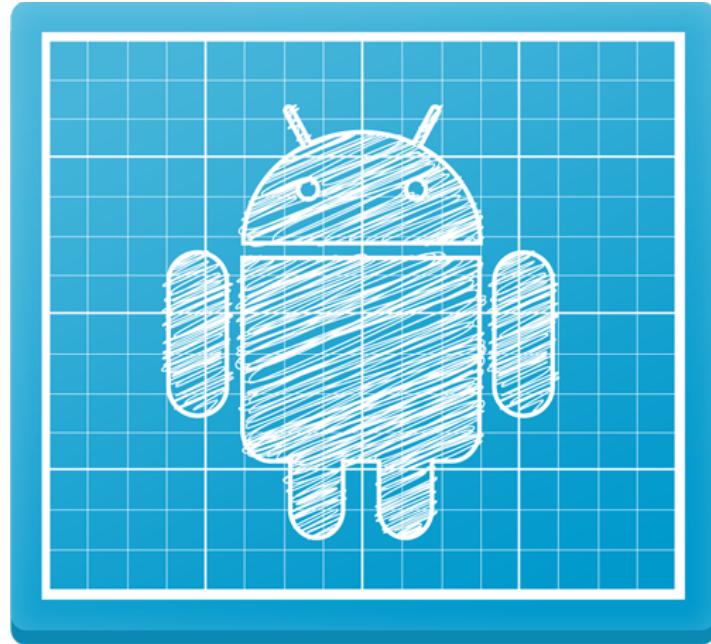
Android 2.2
Android 2.3
Android 3.2
Android 4.0
Android 4.1
Android 4.2
Android 4.3
Android 4.4

8.9% 1.8% 1.3%
6.3%
20.0%
0.1%
16.1%
35.5%

BlueZ
Bluedroid

27%
Android 4.2 – 4.4
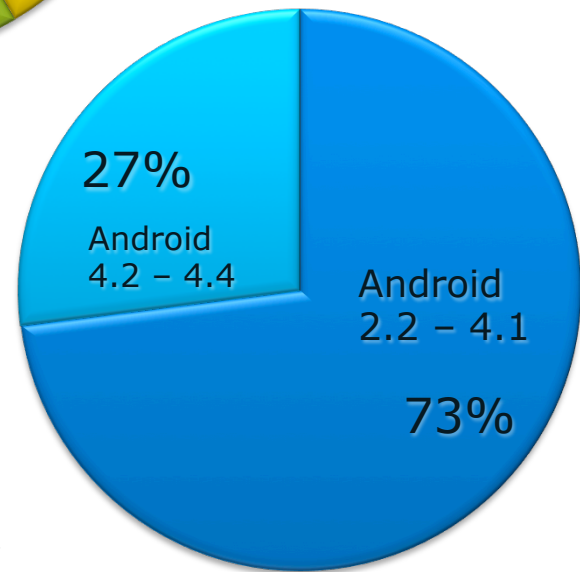
Android 2.2 – 4.1
73%

Data collected during a 7-day period ending on February 4, 2014

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Android 4.2 introduces Bluetooth HAL

Source: https://source.android.com/devices/bluetooth.html
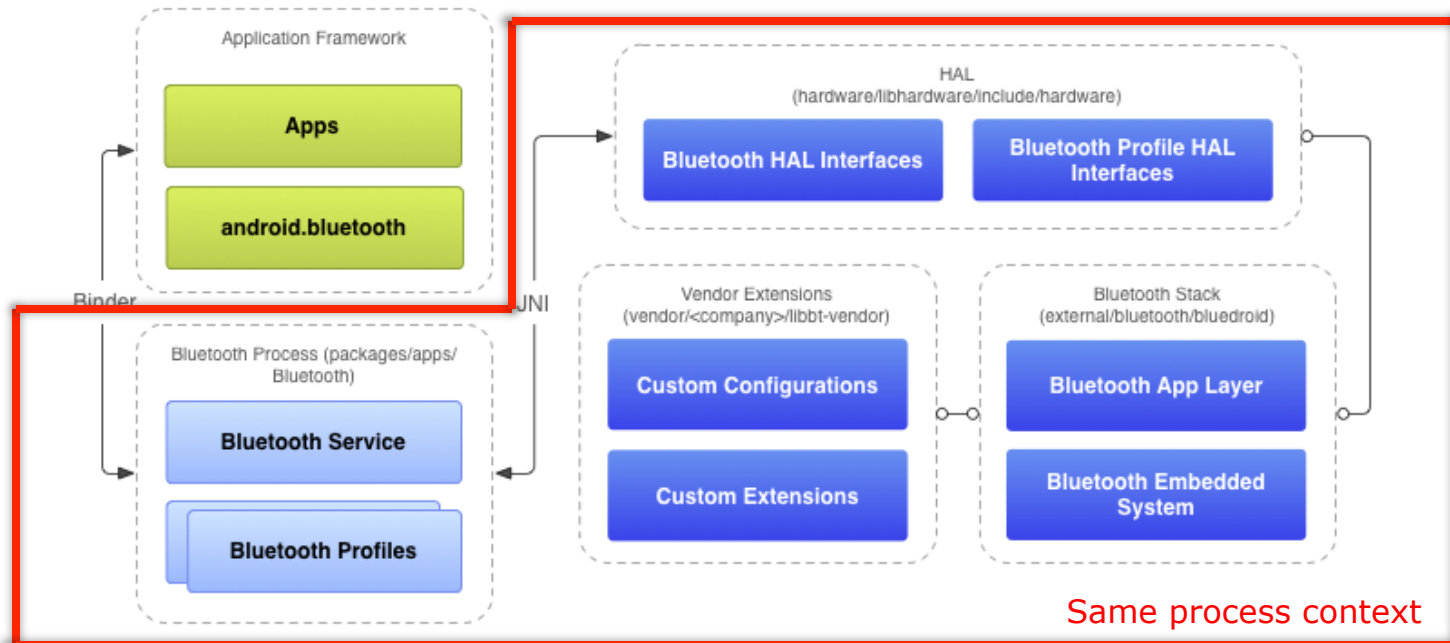
packages/apps/Bluetooth   50,000 SLOC (Java and C++)
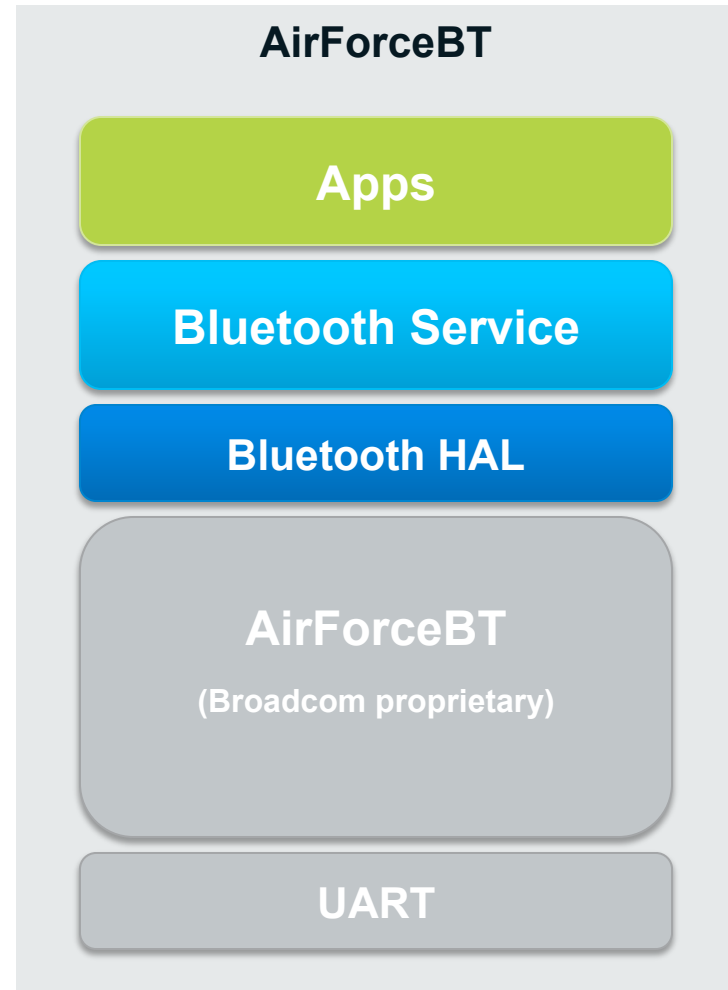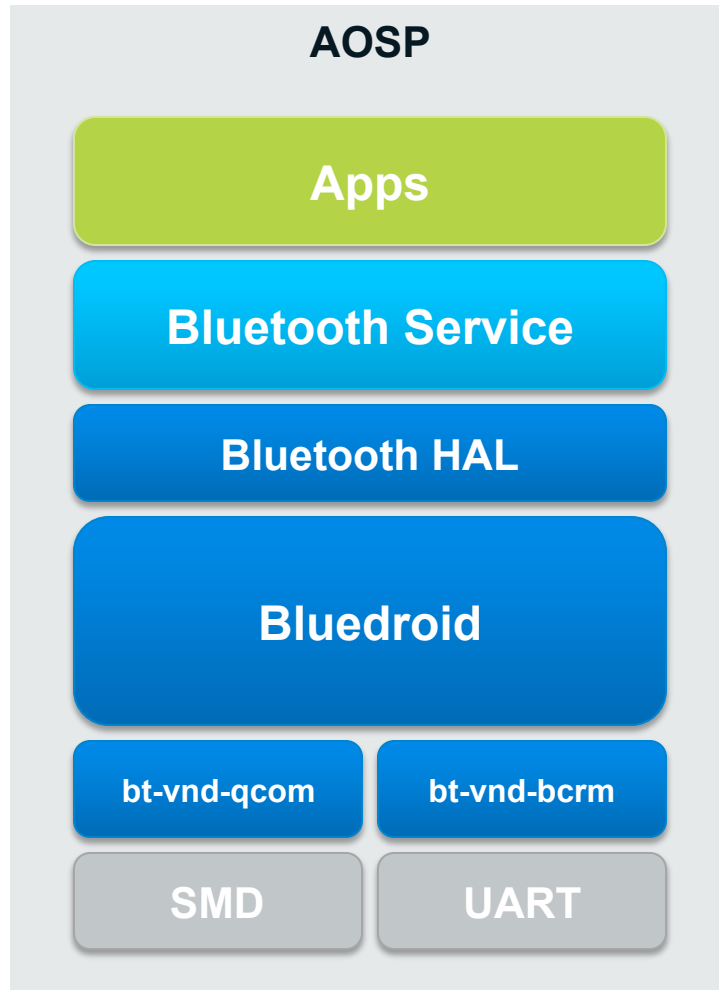external/bluetooth/bluedroid   286,000 SLOC (C and C++)
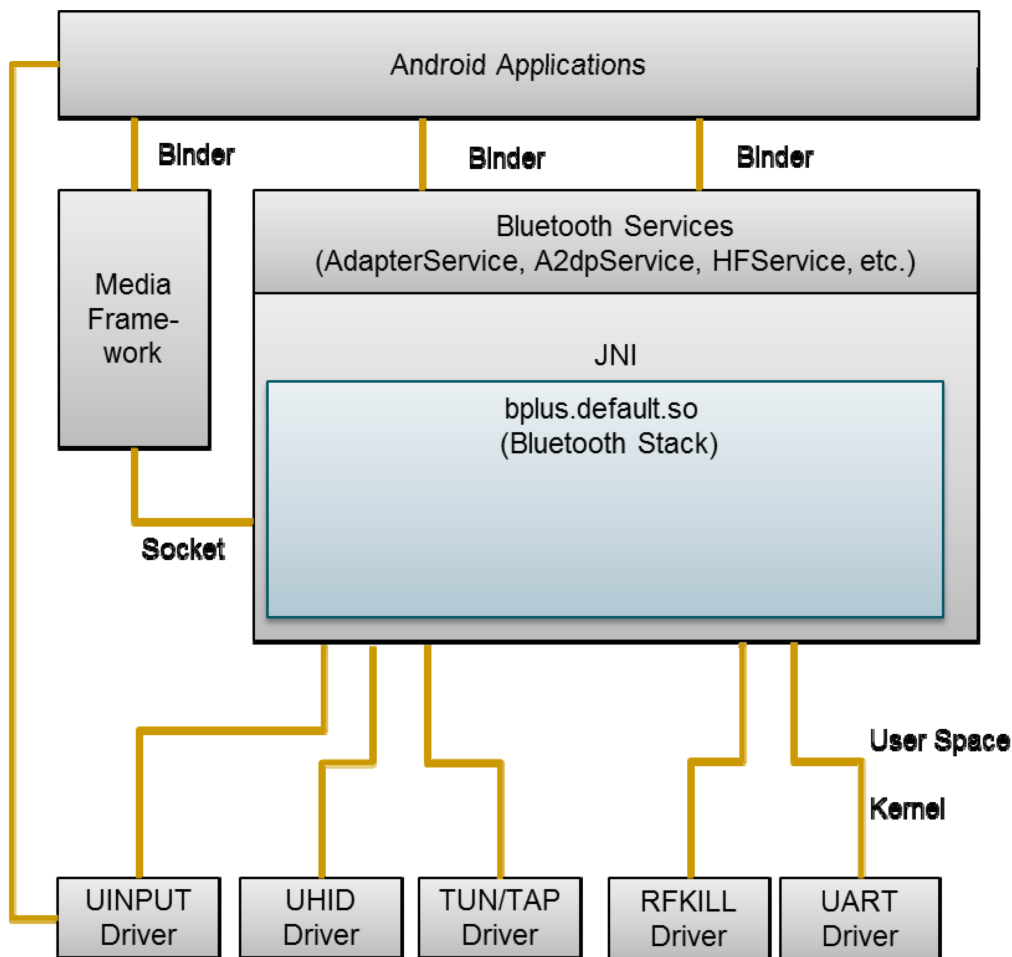
Bluedroid architecture from Broadcom's point of view

Source: AirForceBT_RIN_Datasheet2

Bluedroid requires forking of its source

- Build time configuration for the stack itself, the enabled profiles and also silicon features
- AOSP provides only silicon integration for Nexus 4, Nexus 5 and Nexus 7 devices (Broadcom and Qualcomm)
- Requires shim kernel drivers for silicon integration
- Bus power management done in userspace
- Large new code base (over 286,000 lines of code)
- GIT history starts in December 2012 (only 140 commits)
- No documentation or unit tests are provided
- Extensive audio latency overhead
- Context switches for every HCI packet, audio frame, network packet, HID report and RFCOMM stream
- Limited debugging capabilities
- Missing IA optimization
- Unclear status of 64-bit support
- Only commercial AirForceBT is Bluetooth SIG certified
- Bluetooth 4.1 support is left to the OEM

Current Android Bluetooth world

AOSP

Apps

Bluetooth Service

Bluetooth HAL

Bluedroid

bt-vnd-qcom	bt-vnd-bcrm
SMD	**UART**

AirForceBT

Apps

Bluetooth Service

Bluetooth HAL

AirForceBT

(Broadcom proprietary)

UART

Bluedroid with HCI User Channel

BlueZ for Android

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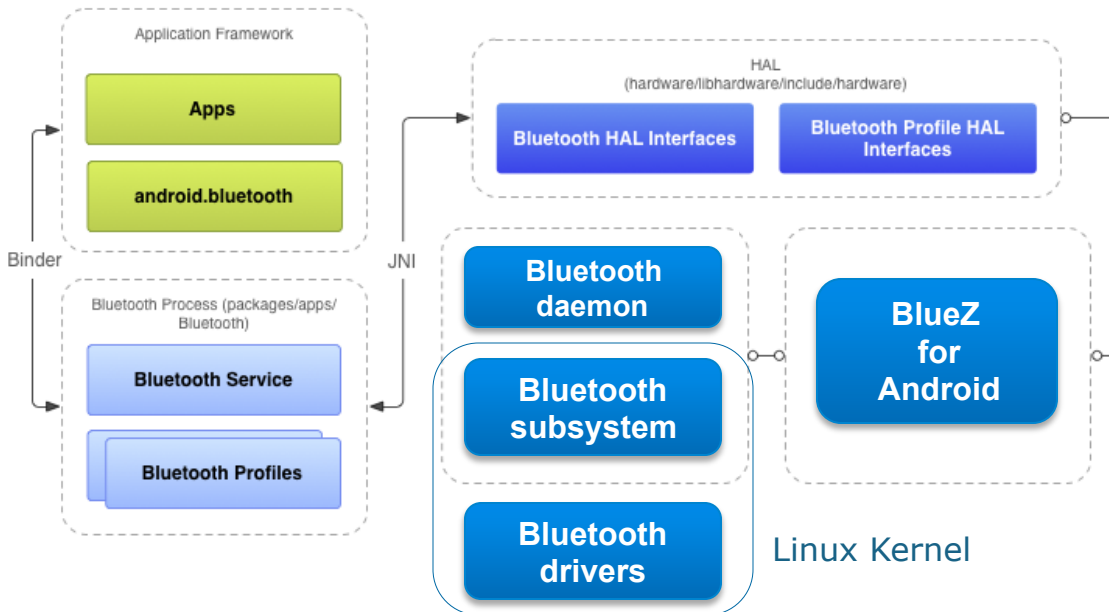
Bluedroid with HCI User Channel

Easy Bluetooth hardware integration

AOSP	AOSP with HCI User Channel	AirForceBT
Apps	**Apps**	**Apps**
Bluetooth Service	**Bluetooth Service**	**Bluetooth Service**
Bluetooth HAL	**Bluetooth HAL**	**Bluetooth HAL**
Bluedroid	**Bluedroid**	**AirForceBT** (Broadcom proprietary)
bt-vnd-qcom / bt-vnd-bcrm	bt-vnd-linux	
SMD / UART	Bluetooth Subsystem	UART

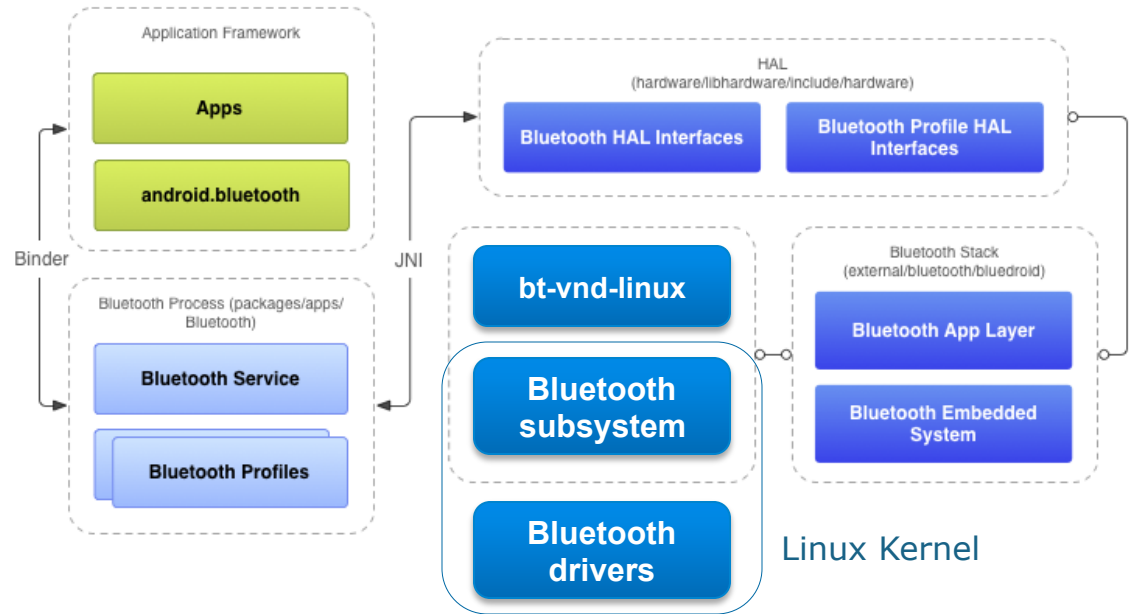(intel)
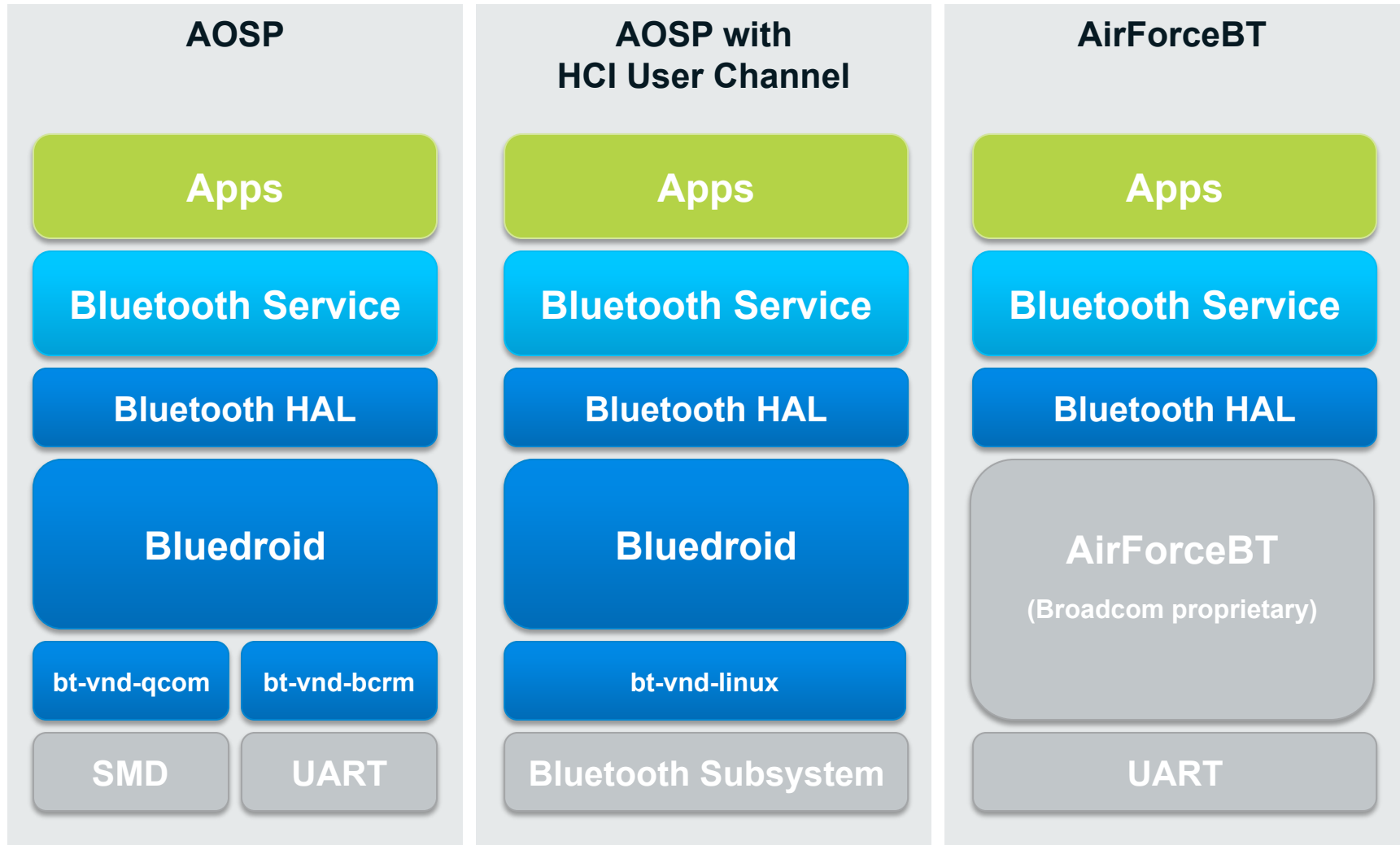
HCI User Channel benefits Bluedroid

- Build time configuration for the stack itself, the enabled profiles and also silicon features
- ~~AOSP provides only silicon integration for Nexus 4, Nexus 5 and Nexus 7 devices (Broadcom and Qualcomm)~~
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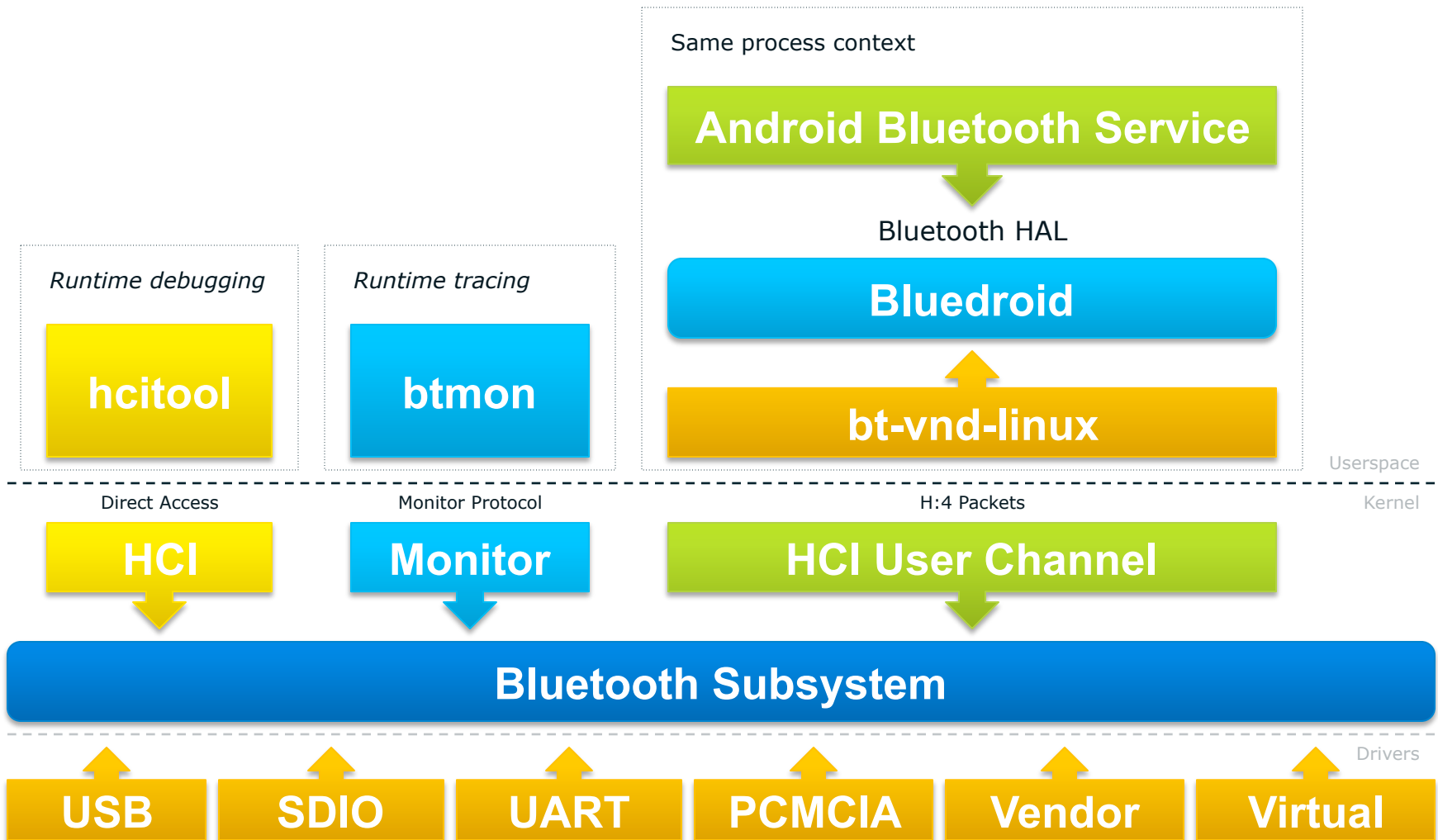- Bluetooth 4.1 support is left to the OEM

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Bluedroid architecture

Bluetooth service

Bluetooth HAL

Bluedroid
(transport, protocols, profiles, audio encoder)

bt-vendor

Audio service

Audio HAL

Bluedroid
(raw audio)

HCI Packets

Ethernet Packets

Input Events

HID Reports

RFCOMM Stream

PCM Frames

Kernel

UART

TUN/TAP

uinput

uHID

AF_UNIX

Bluetooth Silicon

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Bluedroid details

Monolithic architecture without kernel support

- Provides *bluetooth.default.so* and *audio.a2dp.default.so*
- Loaded into process context of Bluetooth Service (JNI)
- Loaded into process context of Audio Service (JNI)
- Expensive communication via Unix Sockets
- Copy of PCM audio frames
- SBC audio encoding is only ARM optimized
- No AES optimization / HCI_LE_Rand for random numbers
- Copy of Ethernet frames for Tethering
- Copy of HID reports through userspace
- Multiple context switches for every single packet

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BlueZ for Android

Replace Bluedroid with BlueZ

- Provide <u>drop-in replacement</u> for Bluedroid
- Similar to what Broadcom does with AirForceBT
- Substitute D-Bus APIs for Android HAL integration

Provide real value add

- Bluetooth 4.1 support
- Full documentation
- Unit tests and end-to-end tests for the whole stack
- PICS, PIXIT and PTS for Bluetooth SIG qualification
- Low-latency and low-power audio support
- 64-bit support
- IA optimized
- Superior architecture

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BlueZ for Android architecture

Bluetooth service
- Bluetooth HAL
- BlueZ (profiles)

Audio service
- Audio HAL
- BlueZ (audio encoder)

Bluetooth Daemon (protocols)

Audio control

System

Control | Socket | Audio frames

Kernel

SMP | HID | BNEP | RFCOMM | 6loWPAN

debugfs | MGMT | L2CAP

Bluetooth Core (including HCI)

Bluetooth Silicon

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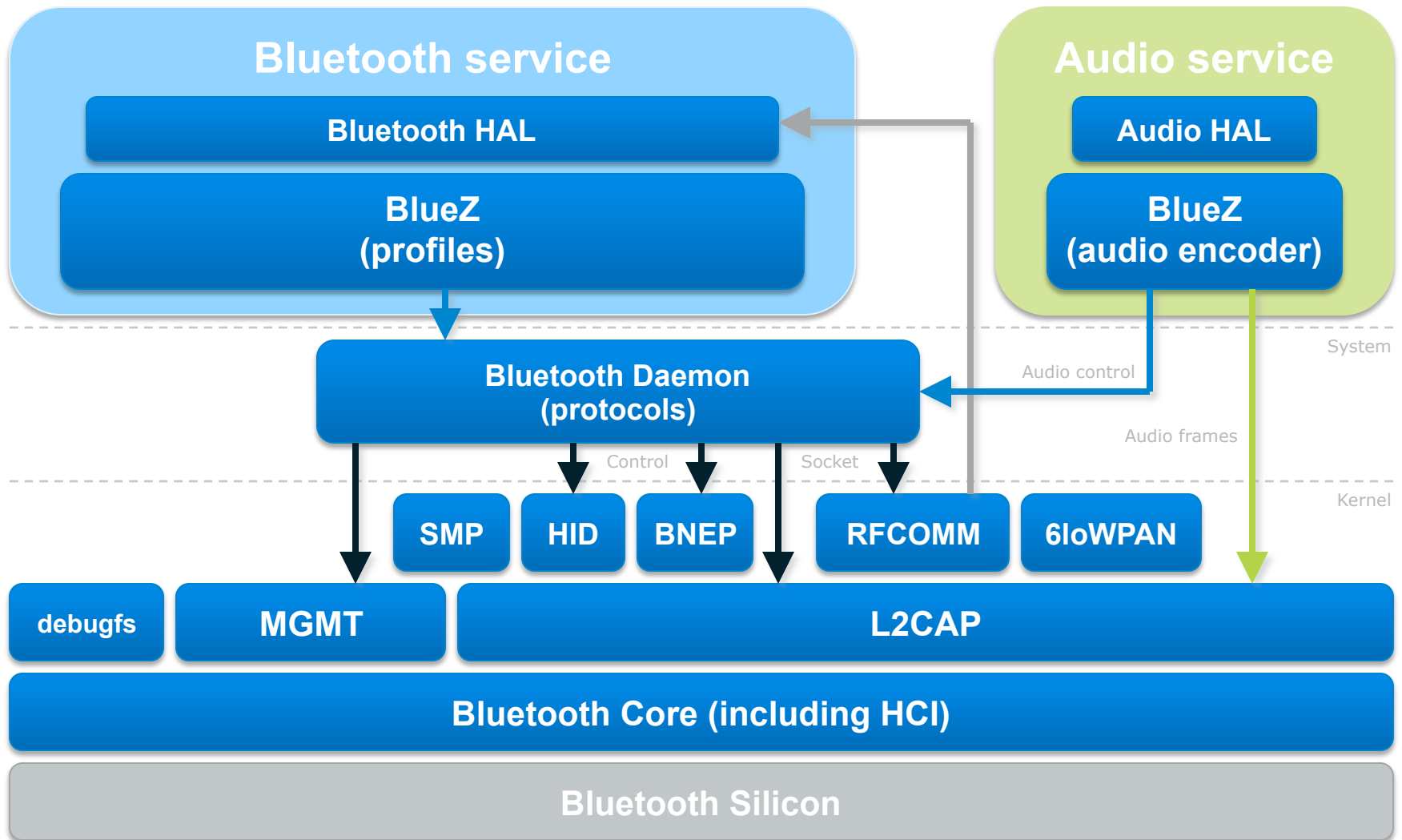
BlueZ for Android details

Modular architecture with kernel subsystem

- Provides profiles via *bluetooth.default.so*
- Provides audio integration via *audio.a2dp.default.so*
- Provides core protocols as kernel subsystem
- Provides additional protocols via userspace daemon
- Bluetooth daemon is started on demand
- All HCI processing is done inside the kernel
- Native L2CAP and RFCOMM sockets
- BNEP Ethernet frames handled inside the kernel
- AES-NI and RDRAND integration
- IA optimized SBC audio codec (libsbc)

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More open source choices

AOSP	AOSP with HCI User Channel	BlueZ for Android
Apps	**Apps**	**Apps**
Bluetooth Service	**Bluetooth Service**	**Bluetooth Service**
Bluetooth HAL	**Bluetooth HAL**	**Bluetooth HAL**
Bluedroid	**Bluedroid**	**BlueZ** (open source)
bt-vnd-qcom / bt-vnd-bcrm	bt-vnd-linux	
SMD / UART	Bluetooth Subsystem	Bluetooth Subsystem

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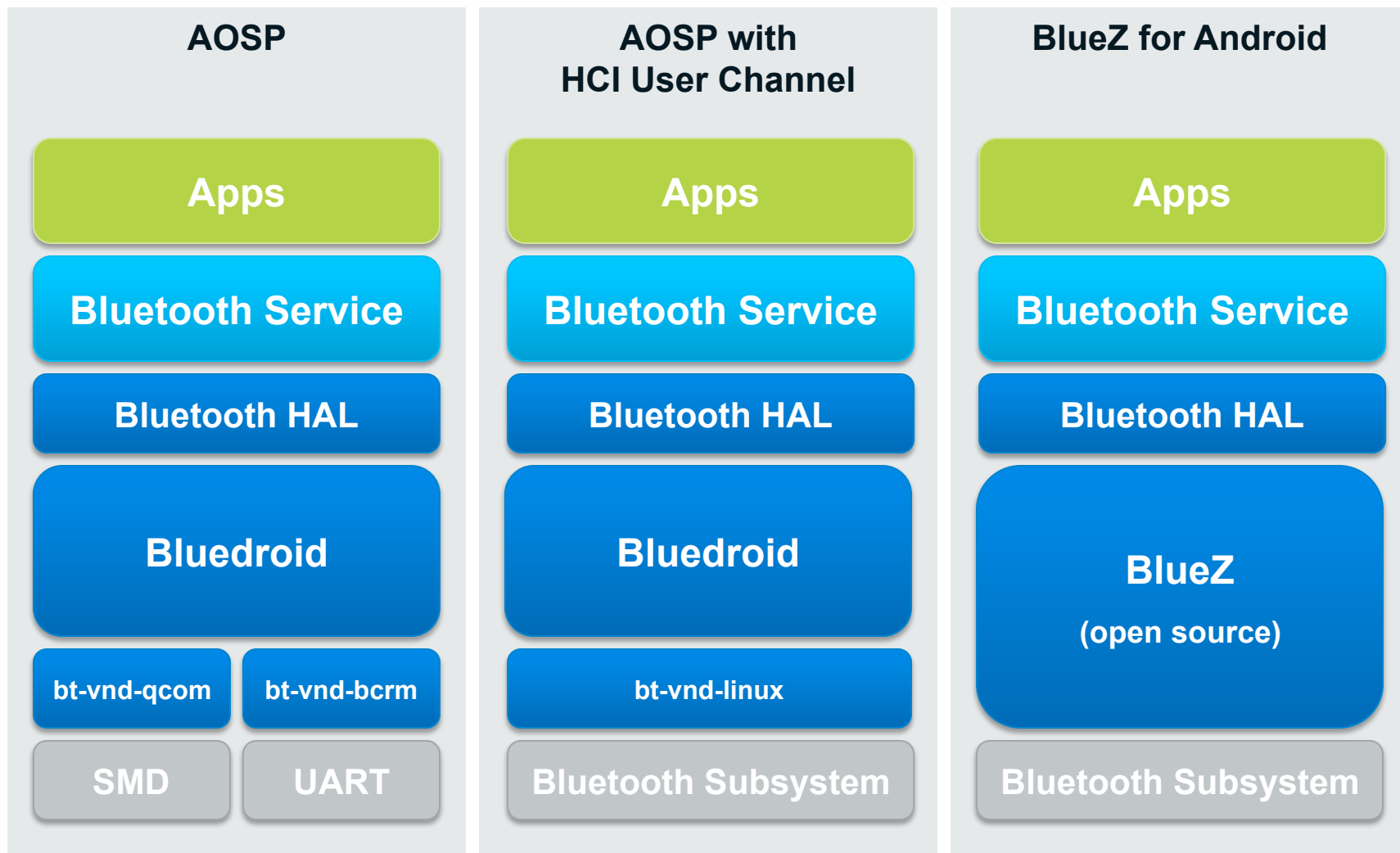
BlueZ for Android to the rescue

- ~~Build time configuration for the stack itself, the enabled profiles and also silicon features~~
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BlueZ for Android status

Available Android features

- Generic Access Profile (GAP)
- Generic Attribute Profile (GATT)
- Device ID Profile (DID 1.3)
- Headset Profile (HSP 1.2)
- Handsfree Profile (HFP 1.5)
- Audio/Video Control Profile (AVRCP 1.3)
- Advanced Audio Distribution Profile (A2DP 1.2)
- Phonebook Access Profile (PBAP 1.1)
- Message Access Profile (MAP 1.1)
- Object Push Profile (OPP 1.0)
- Human Input Devices (HID 1.1)
- Personal Area Networking (PAN 1.0)

Work in progress

- Health Device Profile (HDP)

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BlueZ for Android value add

BlueZ only features

- Dual-mode topology (Bluetooth 4.1)
- BR/EDR Secure Connections (Bluetooth 4.1)
- L2CAP LE Connection Oriented Channels (Bluetooth 4.1)
- IPv6 over LE – 6loWPAN (Internet of Things)
- LE Privacy mode (Tracking protection)
- HFP version 1.6 with Wideband Speech
- AVRCP version 1.5
- A2DP version 1.3
- AAC codec support
- aptX codec support
- SCO over HCI support
- Remote HCI tracing over ADB (including Wireshark)

BlueZ for Android availability

Developed as open source project

- Part of bluez.git upstream source repository
- See android/README to get started
- Qualification instructions at android/{pics,pixit,pts}-*.txt
- Testing overview at doc/test-coverage.txt

Development team credits

```
Szymon Janc                535 (26.5%)
Luiz Augusto von Dentz     291 (14.4%)
Jakub Tyszkowski           213 (10.5%)
Andrei Emeltchenko         210 (10.4%)
Grzegorz Kolodziejczyk     134  (6.6%)
Ravi Kumar Veeramally      134  (6.6%)
Andrzej Kaczmarek          102  (5.0%)
Lukasz Rymanowski           99  (4.9%)
Marcin Kraglak              65  (3.2%)
Sebastian Chlad             64  (3.2%)
Jerzy Kasenberg             55  (2.7%)
Marcel Holtmann             51  (2.5%)
Johan Hedberg               40  (2.0%)
Anderson Lizardo            16  (0.8%)
Claudio Takahasi             7  (0.3%)
Frederic Danis               4  (0.2%)
```

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New BlueZ world view

Fedora, Ubuntu etc.	Genivi	Jolla	Tizen	ChromeOS	Android

User interfaces

BlueZ

BlueZ for Android

Shared Bluetooth Protocols and Profiles

Kernel

Bluetooth Subsystem

Bluetooth Driver

Bluetooth Silicon

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